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ABSTRACT

Computers are integrated into science education when they are used as the most appropriate tool or delivery system to support the goals of science education. The goals of science education can be condensed into two general areas. One area concerns the preparation of a science-literate citizenry; the second area concerns understanding the interrelationships of science, technology, and society. Current uses of computers that support these goals include: (1) direct instruction software, which use drill and practice, tutorials, or a combination of both; (2) exploratory software, which allow students to explore a system, manipulate variables, and observe outcomes (including simulation, problem-solving, and inventory programs); and (3) software used in laboratories, business, and industry (laboratory interfacing systems, word processors, database management systems, spreadsheets, and graphing/numerical analysis). To achieve integration of computers into science education requires planning, preparation, and well-organized classroom management strategies. For decision-makers (the change agents), this requires involving science teachers in an active integration process, providing inservice training, organizing a curriculum development effort, and providing such incentives as release time for curriculum development, stipends for additional work, and recognition for the results. (JN)

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Integrating Microcomputers Into Science Education

by Anne Batey

WHAT DOES INTEGRATING THE COMPUTER INTO SCIENCE CURRICULUM MEAN?

Computer integration does not carry a succinct definition. Definitions are often future tense descriptions of the appearance and activities of a truly computer integrated classroom. Typically these descriptions imply the absence of constraints that we are presently working around, e.g., availability of hardware, high quality software, and teachers who are sufficiently experienced and comfortable with technology in the classroom. It might be helpful to start with a working definition--something in the present tense.

> Computers are integrated into science education when they are used as the most appropriate tool or delivery system to support the goals of science education.

This definition implies two things: first, computer integration does not have to mean regular and varied uses of computers in the science class (in many cases, computer integration may mean a single computer being used whenever an appropriate use is possible); second, computer integration is not the end, but the means to help us reach the end--the goals of science education. Thus, appropriate uses of computers are those that support the goals of science education.

Identifying, developing, and implementing appropriate uses for computers is the central task of computer integration efforts. This report surveys general uses of computers in science that are appropriate for supporting the goals of science education and discusses what is necessary for implementing appropriate uses of computers into science education.

WHAT ARE THE GOALS OF SCIENCE EDUCATION?

The goals of science education can be condensed into two general areas. One area concerns the preparation of a science-literate citizenry, that is, decision-makers, voters, and consumers who are capable of applying the knowledge and processes of science. The second area concerns understanding the interrelationship of science, technology, and society. Here, the emphasis is on the development of values and ethics in understanding the impact of science and technology on society.

In the context of these two broad goal areas, expectations are on the rise. Parents, teachers, and educational

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leaders are eager for improving higher-order thinking skills, critical thinking and problem-solving. Pressure has also increased for improved academic performance in science.

While quite worthy, the goals of science education are elusive. The above goals imply autonomous thinkers who actively question, explore solutions, and reach conclusions. In actual practice, science instruction generally focuses on academic preparation and science content. Science teachers feel burdened by the amount of content to cover in a year and tend to rely on the textbook, lecture, and seatwork for efficient delivery. The computer offers some relief for teachers hoping to reach all goals of science education. With the capacity to manage many inter-related variables, the computer supports situations or experiences that develop systematic thinking about big, complex things. In general, the computer can help create problem-solving or decision-making environments that are complex enough to produce "real" thinking.

WHAT ARE CURRENT USES OF COMPUTERS THAT SUPPORT THE GOALS OF SCIENCE EDUCATION?

Specific computer uses in science are defined by currently available software. There are three general types of software: direct instruction, exploratory, and tool. For each type there are appropriate uses, that when properly implemented, support the goals of science education.

1. Direct Instruction

Direct instruction software uses drill and practice, tutorial, or a combination of both. Well-written direct instruction software is highly interactive; it is not a textbook or workbook-on-a-screen. It employs branching, corrective feedback, and graphics where appropriate. Many packages include useful record-keeping and teacher modification features that save student results and allow the teacher to change the screens, word lists, questions, etc.

While direct instruction has been shown effective at delivering the content of a subject in less time and with good retention, there is a catch. Gains occur when students have regular, repeated sessions wtih the software. So, if computer access is limited, direct instruction should be used with individuals needing extra help with science content, e.g., makeup work after extended absence or transfer, review and remediation for weaker students, and extra attention for students with special needs. Using direct instruction software for these students should not exclude other students from opportunities at the computer.

2. Exploratory

Exploratory software allows students to explore a system, manipulate variables and observe outcomes. This type of software can be divided into three groups: simulation, problem-solving, and inventory.

- <u>Simulations</u> model real-world systems, devices, or events. They are valuable for recreating what cannot take place in a classroom or laboratory. Examples include: studying genetic traits of many generations of animals, operating a nuclear power plant, and viewing the motions of planets and stars at an observatory or planetarium.

  Simulations are an excellent vehicle for teaching analysis, synthesis, and evaluation. It is difficult to conduct experiments in the classroom that give the "big picture", allowing students to explore the interactions of all the components in a complex system. As in the examples above, some systems can only be studied as simulations. Without the limits of time, space, or potential danger, students can observe the effects of a change in any component to all of the others. With proper guidance from the teacher, students develop the ability to find relationships in the system and make accurate predictions about the effects of changes. A study on the use of biology simulations with guidance from the teacher, found that students using simulations performed better on subsequent tests of scientific and critical thinking than those not using guided simulations.

Well-organized simulation activities do not require a lot of computer access. Many simulations work best as a team activity. Research, planning, and analysis are done away from the computer, while the team prepares for a new test or change to the system. Simple simulations that animate a process or device found in science labs, can be appropriately used as an introduction or practice. But, such simulations should not replace actual lab experiences.

- Problem-solving software isolates and explores a range of skills: logical operations, deductive and inductive reasoning, pattern recognition, classification, and prediction from generalization, etc.

- Inventories survey students on some aspect of their lifestyle, e.g., diet, habits, energy use, etc. and then analyze the results by comparing them to statistical norms. They generate interest and motivation, promoting self-awareness and consideration of personal choices. For instance, seeing a sharp decrease in projected life expectancy is much more vivid than reading or hearing about the effects of smoking.

3. Tools

Software used in laboratories, business and industry are grouped together as tool software. There are five categories of tools that are appropriate for use in science education: lab interfacing, word processing, database management, spreadsheet, and graphing and numerical analysis.

- Lab interfacing systems combine hardware and software to make the computer a data collection and analysis tool. Data is collected with various sensors capable of measuring changes in temperature, light, motion, sound, conductivity, etc. The results are plotted as they are measured on a graph, or some other appropriate display. The computer makes data collection and display more immediate and efficient. The student's experience is focused on interpretation of results. As with simulations, the computer is used appropriately if the interfacing system extends and does not replace a student's lab experience.

- Word processors create, edit, format, and save text for lab write-ups and research papers. Because revising an inadequate conclusion or adding important information is less painful with a word processor, teachers can increase their expectations for students' written communication of science. Student comments during post-lab debriefing or group discussion of science in society issues can easily be saved, organized, and printed for subsequent analysis.

- Database management systems support information processing activities that isolate and practice skills closely related to scientific inquiry. When creating the database, students select and organize information (classification). The search and sort features of a database can readily find patterns and relationships in the data (synthesis). From patterns and relationships in information, students can make generalizations and predictions (inference).

- Spreadsheets encourage students to experiment with the possibilities of a system of numerically interrelated variables. For example, with a spreadsheet on electric power consumption constructed with total consumption and cost at the home, community, state, and national level, students can explore and immediately see the impact, at all these levels, of changes in appliance usage. This tool supports analysis and an understanding of interrelationships.

- Graphing and numerical analysis software displays lab results in a variety of ways. It will also do numerical analysis of the results. As with lab interfacing, this software helps to focus a lab exercise on interpreting results rather than displaying measurements.

WHAT DOES IT TAKE TO ACHIEVE INTEGRATION OF COMPUTERS INTO SCIENCE EDUCATION?

Integration requires a lot of planning and preparation. First in line for preparation are the science teachers. Teachers new to computers need a sequence of workshops that begin with computer awareness and continue to hands-on experiences with computer uses similar to those mentioned above. Teachers need to reach a point of familiarity with computer uses where they are capable of defining and developing lessons that use the computer appropriately.

Integration requires curriculum development. As with any instructional media, computer lessons have objectives, supporting activities, and materials. Teachers need the opportunity to thoroughly preview software for its use in the classroom, determining if (and where) the software meets the goals of science education and matches the classroom objectives. Next, they either redesign existing lessons to include the computer portion or design new, enhanced lessons using computers, expanding objectives and replacing existing methods and content. In each case, they must design the sequence of activities and develop or gather handouts and resources.

Integration requires well-organized classroom management strategies. Limited computer access is the biggest management obstacle. Individual lessons using the computer will require different strategies. Careful orchestration of small group tasks is often the best method to get mileage out of a single computer. In such lessons, the computer is one station or learning center out of many in the classroom. Groups of student move from station to station by some prearranged procedure. Another strategy is to hook the computer to a large screen monitor and make it a demonstration center for a whole class activity. In addition to managing computer access, teachers must prepare rules and procedures for handling the software and hardware.

WHAT ARE THE IMPLICATIONS FOR DECISION-MAKERS?

Ultimately, a computer integrated science classroom will look a lot like the more lab-oriented science classrooms. Such classrooms regularly have small groups of students working simultaneously around the room, moving to get and replace equipment, conducting one activity at one place and moving to another place for a different activity. In general, such classrooms are more learner-centered with active students working responsibly in small groups. Classrooms that have emphasized lecture and seatwork will require greater change to make the move to computer integration.

For decision-makers it's the same old/new story; you must support change. As change agents, the following suggestions may be useful:

- Involve the science teachers in an active integration process.

- Provide for inservice that will prepare science teachers to integrate computers. Such inservice should include, along with computer experiences, preparation for curriculum development and classroom management strategies.

- Organize a curriculum development effort. Bring the science teachers together to design and develop lessons and units integrating the computer. Identify a leader or leaders, those who are using computers and those whose science classrooms look like the ones just described.

- Provide incentives: release time for development and modification of the curriculum, stipends for additional work, and recognition for the results. Recognition might involve: publishing and distributing the lessons or units, news releases on what's taken place in the science classroom, or encouraging conference presentations by the teachers involved in the development.

RESOURCES

Holdzkom, D. and Lutz, P., eds. Research Within Reach: Science Education. Report prepared by Appalachia Educational Laboratory for National Institute of Education, 1984. (available through ERIC: ED 247 148)

A research synthesis that discusses the curriculum development projects of the 1960's, the goals of science education, and effective methods for science instruction including the role of computers.

McCollum, P., "Choosing Software for a High School Chemistry Class", T.H.E. Journal, pp. 90-93; October 1985.

A chemistry teacher describes her process for integrating computers. It includes discussion of classroom logistics, hardware, suitable software, and security and maintenance.

Shavelson, R. et al, Teaching Mathematics and Science: Patterns of Microcomputer Use. Santa Monica, California: The Rand Corporation, 1984.

This report summarizes the results of a study on "successful" teachers' microcomputer-based math and science instruction. It discusses four patterns of use found in 60 teachers who were regular users of computers in instruction. It also includes recommendations for staff development and courseware.

Vockell, E. and Rivers, R. "Computerized Science Simulations, Stimulus to Generalized Problem Solving Capabilities". Paper presented at annual convention of the American Education Research Association, New Orleans, Louisiana, April 1984. (available through ERIC: ED 253 397)

LIBRA Project Evaluation Reports: Set of 99 on Science Courseware, January 1985, Northwest Regional Educational Laboratory, Marketing Office, 300 S.W. Sixth Avenue, Portland, Oregon 97204, $25.00.

This special set of 99 MicroSIFT evaluations focuses on secondary science software.
